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Research Article

Survey of the Causes of Brake Failure in Commercial Mini-buses in Kumasi

[1]Prince Owusu-Ansah, [1]Timothy Alhassan, [1]Alex Frimpong and [2]A. Agyei Agyemang
[1]Department of Mechanical Engineering, Kumasi Polytechnic, P.O. Box 854, Kumasi, Ghana
[2]Department of Mechanical Engineering, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana

Abstract: This paper studies the causes of brake failure in commercial mini-buses in Kumasi, Ghana. A structured questionnaire was administered at (20) bus terminals, (65) automotive workshops and (25) government institutions. The researcher met the personnel in charge of these institutions and explained the objectives of the research. The questionnaire was left with the authorities overseeing these institutions and the response was collected at a later date. In all a total of (485) people were surveyed. The results and responses suggested that the main causes of brake failure in mini-buses are: Overheating of the brake assembly due to prolong application of the brakes, low brake fluid level as a result of defective rubber seals in the master cylinder and air trapped in the braking system resulting in spongy brakes and reducing braking efficiency. The survey results showed that brake failure in commercial mini-buses is caused mainly by Overheating of the brake assembly due to prolong application of the brakes. The survey responses suggest that the braking system should be inspected and serviced periodically in order to minimize the rate of brake failure in mini-buses.

Keywords: Brake failure, brakes, braking efficiency, master cylinder

INTRODUCTION

When a vehicle is accelerated, energy supplied by the engine causes the vehicle's speed to increase. Part of this energy is instantly used up in overcoming frictional and tractive resistance but a large amount of it remains stored in the vehicle. This energy of motion is called the kinetic energy (Hillier, 1991). The existence of kinetic energy is observed when a vehicle is moving and neutral gear is selected. The vehicle does not immediately come to rest, instead it travels for a considerable distance before it becomes stationary. In this case the stored energy is used to drive the vehicle against the resistances that oppose the vehicle's motion.

Relying on these resistances to slow down a vehicle could cause many problems, so an additional resistance called a brake is needed to convert the kinetic energy to heat energy at a faster rate in order to reduce the speed of the vehicle. This reduces the speed of the vehicle at a faster rate and brings the vehicle to rest within the shortest possible time when the brakes are applied.

To bring a vehicle to a stop, the brakes have to absorb all the energy given to the vehicle by the engine and that due to the momentum of the vehicle. This energy must then be dissipated. In most vehicle brakes, the energy is absorbed by friction, converted into heat and the heat dissipated to the surrounding air. As the energy is absorbed, the vehicle is slowed down; in other words, its motion is retarded. The brakes must also pull up the vehicle smoothly and in a straight line. The road wheels of the vehicle may be retarded or braked by means of drum or disc friction brakes, or by a friction brake which is applied to some part of the transmission system.

Types of braking systems: There are two main types of braking systems used in motor vehicles. These are:

- The Drum brake assembly
- The Disc brake assembly

Drum brake assembly: The drum brake is an internally expanding type of brake that uses two shoes attached to a back-plate, which is fixed to a stub axle or axle tube. Each shoe has a 'T' section and a friction lining riveted or bonded to its outer face. At one end of the shoe is fitted a device for expanding the shoe when the brake pedal is depressed. In a simple brake, such as that shown in Fig. 1, a cam is used as a shoe expander, but modern layouts fitted to cars are hydraulically operated pistons for this purpose.

All shoe-type brakes must have some arrangement to prevent the shoes rotating with the drum. The shoe anchor, which must be rigidly attached to the back-plate, takes the form of a large pin that passes through the shoes, or a housing, against which the shoes butt.

Corresponding Author: Prince Owusu-Ansah, Department of Mechanical Engineering, Kumasi Polytechnic, P.O. Box 854, Kumasi, Ghana

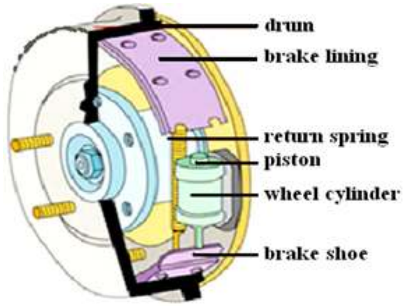

Fig. 1: The drum brake assembly

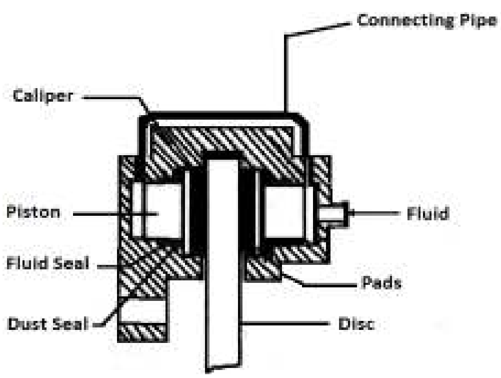

Fig. 2: Disc brake

Springs pull the brake shoes on to the back-plate and also return the shoes to the 'off' position after the brake has been applied. In some cases separate springs are used to perform the retention and return functions. The inner cylindrical surface of the cast iron drum is ground to give a smooth surface on to which the brake linings can rub. The drum is generally attached to the hub flange by small counter-sunk screws and retained securely by the wheel nuts. If possible, the drums should be exposed so that a good flow of air over the drum is achieved to dissipate the heat and prevent loss of brake efficiency that occurs when the unit gets very hot. Some form of adjuster is provided for each brake to take up excessive clearance due to wear of the friction facing. Since a large leverage is needed between the brake pedal and shoe, a large movement of the shoe would mean that the brake is fully applied. This dangerous condition is avoided by either manually adjusting the brakes periodically, or having an automatic adjuster that continually sets the shoes so that they are always positioned very close to the drum (Heisler, 1989).

The drum brake assembly consists of the following components:

- Wheel cylinder
- Master cylinder
- Back plate
- Brake shoes
- Brake drum
- Springs

Advantages and disadvantages: The main advantages of the drum brake are:

- The same braking power is available in reverse as well as when moving forward.
- Drum brakes give a greater stopping force for a given size of brake drum.
- Drum brakes have self servo action which gives effective braking.

The main disadvantages of the drum brake are:

- Loss of braking power is more evident during prolong braking which results in overheating of the system.
- The system is more complicated in design.
- Uneven wearing of the braking lining results in vehicle pulling to one side during braking period.
- One problem with drum brakes is fade (This is a condition where the brake performance falls drastically when a brake, especially the friction linings, reaches a given temperature).

Disc brakes assembly: The disc brake consists of an exposed disc which is attached to the hub flange; the two friction pads are pressed on to this disc to give a braking action. Figure 2 shows a disc brake assembly. The pads are moved by hydraulic pistons working in cylinders formed in a caliper that is secured to a fixed part of the axle. When the hydraulic pressure is applied to the two cylinders held in the fixed caliper, the pistons move; this action forces the friction pads into contact with the rotating cast iron disc. The sandwiching action of the pads on the disc gives a retarding action and heat generated from the energy of motion is conducted to the disc.

Greater part of the disc is exposed to the air, therefore heat is easily radiated, with the result that the brake can be used continuously for long periods before serious fade occurs. Since the friction pads move at a right angle to the disc, any drop in the friction value does not affect the force applied to the pad. As a result this type of brake is not very sensitive to heat (Mudd, 1972a, b). The disc brake was developed to minimize the fade problems. When fading occurs, the driver has to apply a much larger effort and in extreme cases it becomes impossible to bring the vehicle to rest. The problem arises when a drum brake is continually operated for long periods, as when a vehicle descends a long mountain road. The friction between the lining and drum and the effect of this friction on the application of the shoes, govern the maximum braking torque that a drum brake can produce. Although friction materials having good anti-fade qualities are produced, there is still the chance of fade with a drum brake.

No assistance is obtained from the rotating disc to aid the driver in the application of a disc brake to achieve a given retardation. A disc brake requires a greater pedal pressure than that needed for a drum brake. Adjustment to take up pad wear is automatic on a disc brake, therefore minimum attention is required. A merit of this type is the ease with which the pads can be inspected. If corrosion is not present, the pads can be easily renewed.

The disc brake assembly consists of the following components:

- Master cylinder
- Brake pads
- Brake discs
- Rotor

Advantages of the disc brakes: Disc brakes have the following advantages over drum brakes.

Greater heat dissipation: This is because only small part of the disc is heated by contact with the pads, the greater part always being in contact with the stream of cooling air. Brake fade is therefore greatly reduced and pedal travel remains fairly constant.

Cleaner braking surfaces: Centrifugal force throws water, dirt and oil off the discs, which therefore retain their efficiency and are worn less. The discs are more substantial and so less liable to distortion than drums.

Lighter in weight: The disc brake assembly is about 20% less in weight than the equivalent drum type.

Simpler construction: Pads are visible and wear is easy to observe or see.

Easier maintenance: Brake pads can be changed much quicker than brake shoes.

Disadvantages of disc brakes:

- The disc brake has no self servo action, therefore higher operating forces and pressures are required. In-spite of this feature the disc brake, particularly when used with a hydraulic servo unit, provides a braking effort which is directly proportional to the applied pedal force.
- The higher operating forces required complicate the design of the hand-brake mechanism. For this reason many cars are fitted with disc brakes at the front wheels only.

Brake fluid: The fluid used in the hydraulic brake systems is a vegetable oil with certain additives. The main requirements of a good brake fluid include low viscosity, high boiling point, compatibility with rubber components, lubricating properties, resistance to chemical ageing and compatibility with other fluids according to Nunney *et al*. (1998). However, most Ghanaian drivers use other fluid such as dirty brake fluid, less dirty fluid and even soapy water as substitute to the original brake fluid.

Fluid contamination: It is even more important that engine oil, shock absorber oil, petrol and paraffin never be introduced into a fluid brake system-nor should they ever be used to clean brake parts. The use of these mineral-based oils results in the rapid weakening or destruction of all the rubber components and possibly in the injury or death of the vehicle users as a result of brake failure. Cleaning should always be done with industrial methylated spirit, followed by washing in clean brake fluid and/or application of the correct rubber grease. A system contaminated by mineral oils or wrong fluids must be thoroughly flushed out with methylated spirit, have the contaminated fluid destroyed at once and all rubber parts replaced.

Flushing is similar to normal bleeding except that the fluid is replaced by methylated spirit and at least a litre of spirit passed through each bleed valve. Flushing should be carried out once every 3 years of normal service and whenever the fluid appears thick and dirty (Reed and Reid, 2000).

Anti-lock Braking System (ABS): There is an increasing need for systems that provide better safety, as the number of vehicles that use the road. A braking system that incorporates an arrangement that prevents the road wheels from locking up and skidding should contribute to this extra safety required if used correctly.

A driver finds it difficult to assess the force that should be applied to the brake pedal to make an emergency stop and bring the vehicle to rest in the shortest possible distance. This is because it is an impossible task to take into account the many varying factors such as type and roughness of the road and tyre and the condition of the surfaces; e.g., wet, dry, greasy or icy. This generally means that the driver applies either too much or too little pressure on the pedal. The effects of such actions are:

- **Pedal pressure too high:** One or more of the wheels may skid over the surface with the result that:
  - Stopping distance is increased because the adhesion between a skidding wheel and the road is less than that given by a wheel that is held on the verge of skidding.
  - **Directional control is jeopardized:** In the case of a rear-wheel skid, the vehicle turns from front to rear.
- **Pedal pressure too low:** Stopping distance is increased, which can result in impact with an object.

The adhesion between the road wheel and road surface is governed by the coefficient of friction. This varies considerably when the condition of the road surface is changed. For example, the friction value of a dry asphalt road falls by about 0.8 to 0.15 when it is covered with black ice.

On a dry surface the adhesion varies as the percentage of wheel slip changes from 0 to 100%. Retention of steer ability in maximum braking situations and avoidance of skid danger under all road conditions are the basic requirements of a good anti-locking system. The system should be fail-safe, low in weight and the initial cost should be reasonable.

The systems in use differ in the method that is used to sense wheel slip. The systems of ABS available are:

- Mechanic
- Electronic

The layout of the main components of a four-wheel regulated system is similar to that produced by Association of Technical Engineers ('ATE'). The system may be divided into two sub-systems: Hydraulic and Electronic.

MATERIALS AND METHODS

Survey: A structured questionnaire was administered at (20) bus terminals, (65) automotive workshops and (25) government institutions. The researcher met the personnel in charge of these institutions and explained the objectives of the research. The questionnaire was left with the authorities overseeing these institutions and the response was collected at a later date.

Bus terminals, automotive workshops and government institutions fall into several categories. Due to the different categories, random sampling was used to select the sampling units. Stratified random sampling was used to select samples in situation where population is heterogeneous but has definite strata or classes which are homogeneous (Kalton and Moses, 1989). Kejetia bus terminal and Suame magazine were investigated and the sample units taken.

RESULTS AND DISCUSSION

Survey responses: Out of a total number of four hundred and (485) people interviewed, (132) representing 27.2% indicated that the brake failure they experienced was as a result of low brake fluid level in the master cylinder. One hundred and nine representing 22.4% indicated that overheating was the main cause of the brake failure they experienced in commercial mini buses whiles (65) people representing 13.4% indicated that air trapped in the system caused the brake failure.

The results from the survey indicated that (306) representing 63% indicated that low brake fluid level in the master cylinder, overheating of the brake assembly and air trapped in the braking system was the main causes of brake failure, whiles results obtained from the experiment showed that when the brakes were operated under hot condition even with the use of the servo, the braking force was much lower than when higher pedal force was applied, which meant that the braking efficiency was very low. The viscosity temperature graph indicates that the brake fluid became less viscous as a result of the temperature effect which affected the braking efficiency.

From the survey it was observed that most cases having dirty brake fluid, had low brake fluid levels. This may be because the brake rubber seals were attacked which created a leakage and resulted in the brake fluid leaking out from the master cylinder and resulting in low brake fluid level. This could also have resulted in air being trapped into the system. The effect was that, the pedal force which was meant to transmit fluid in order to achieve a high braking force was rather used to compress the air which was trapped in the pipelines.

Responses to questionnaire: It was observed that out of the total number of (485), (132) representing 27.2% did indicate that low brake fluid level in the master cylinder did cause brake failure. One hundred and nine representing 22.5% attributed the cause of brake failure to overheating of the brake assembly, while (65), representing 13.4% said the cause of brake failure was air being trapped in the pipeline.

The results from the survey show that out of the various causes that are attributed to brake failure, low brake fluid, overheating of the brake assembly and air trapped in the pipeline which amounted to 63.1% indicates that they are the most often causes of brake failure in mini-commercial buses.

The rest of the results were: twenty nine representing 5.9%, stating that grease or brake fluid on lining was the cause, (17) representing 3.5% said incorrect shoe adjustment, while (10) people representing 2.1% attributed uneven tyre pressure and brake shoe adjustment as the cause of brake failure. Automatic shoe adjuster not functioning, poor or wrong lining fitted into the brake assembly and master cylinder or wheel cap being soft and sticky had (16), (20) and (26) representing 3.3, 4.1 and 5.4%, respectively in commercial mini buses, while (28) people representing 5.7% attributed brake failure to causes different from what was stated in the questionnaire.

Table 1 gives the causes of brake failure in commercial mini-buses. Figure 3 shows a bar chart of the results in Table 1.

Servicing periods: The servicing period gives the number of times the people who answered the questionnaire service their brakes. With reference to the

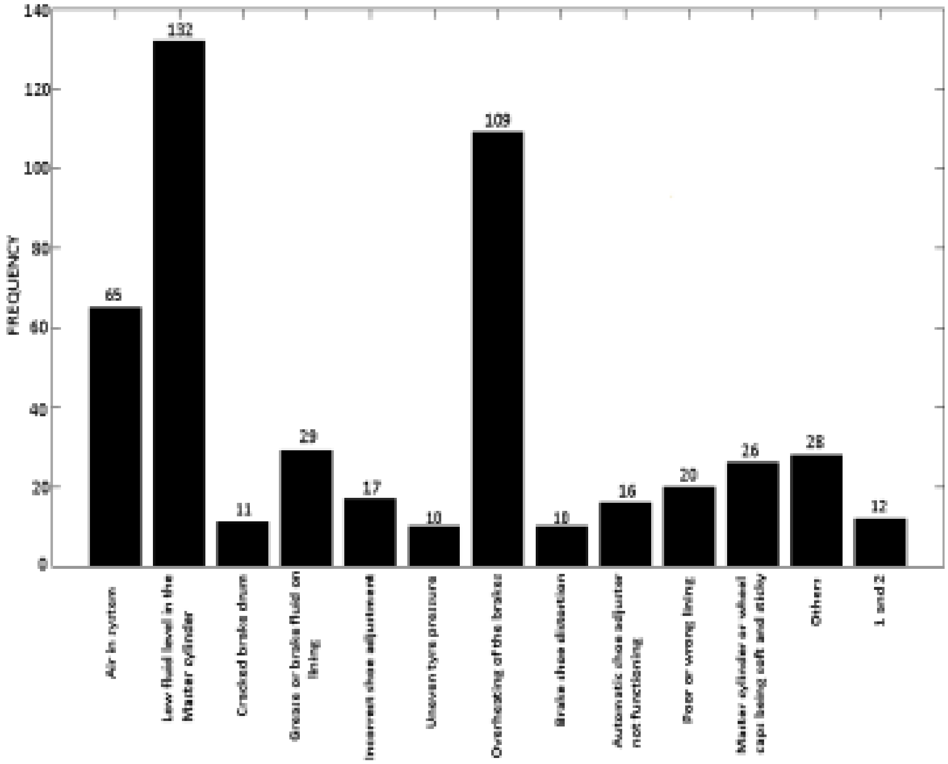

Fig. 3: Causes of brake failure in commercial mini-buses

Table 1: Causes of brake failure in commercial mini-buses

Causes of brake failure	Total	(%)
Air in system	65	13.4
Low fluid level in the master cylinder	132	27.2
Cracked brake drum	11	2.3
Grease or brake fluid on lining	29	5.9
Incorrect shoe adjustment	17	3.5
Uneven tyre pressure	10	2.1
Overheating of the brakes	109	22.5
Brake shoe distortion	10	2.1
Automatic shoe adjuster not functioning	16	3.3
Poor or wrong lining	20	4.1
Master cylinder or wheel caps being soft and sticky	26	5.4
Others	28	5.7
1 and 2	12	2.5

Table 2: Servicing periods

Periods	Total	(%)
One month	29	6
Three months	41	8
Six months	104	22
One year	310	64

graph, it clearly reveals that (310) people repair their brakes yearly, which could be attributed to the various causes of brake failure. If out of (485), 310 representing 64% people service their brakes yearly, then the conclusion can be drawn that people do not service their brakes regularly. This may be the cause of the frequent brake failure.

Out of the 485, 104 representing 22% stated that they service their brakes every 6 months. Twenty nine

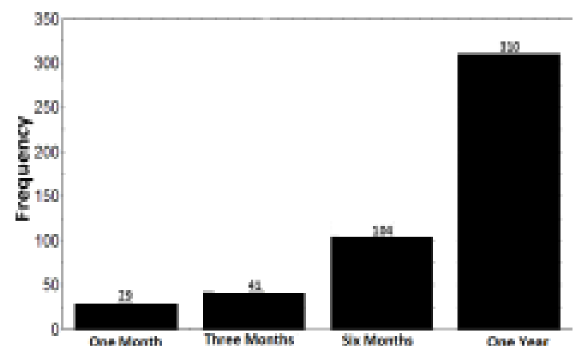

Fig. 4: Brake servicing periods

and 41 people representing 6 and 8%, respectively service their brakes every month and every three months, respectively. A critical analysis shows that few people could afford to have their brakes checked on monthly bases. This may be the cause of the numerous brake failures in commercial mini buses.

Table 2 gives the results of the survey as far as servicing periods was concerned. Figure 4 shows the periods within which the respondents service their brakes.

Brake failure results in accident: Figure 5 shows the survey results of brake failure cases that resulted in accidents. It was observed that out of a total number of (485), (392) representing 81% did results in road accident. Clearly the survey reveals that most accidents

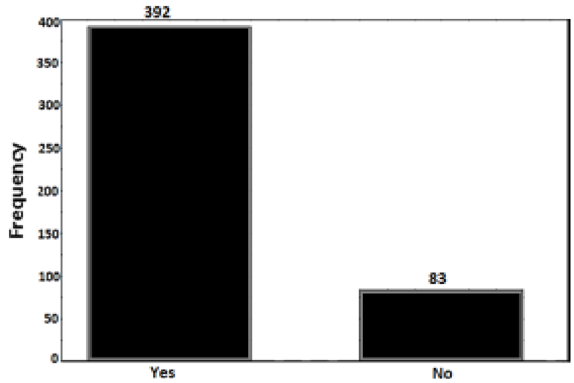

Fig. 5: Brake failures that resulted in accident

on our road associated with commercial mini-buses is as a result of brake failure and as a result all effort must be made to reduce it or if possible avoid brake failure completely.

CONCLUSION

The survey results showed that brake failure in commercial mini-buses is caused mainly by Overheating of the brake assembly due to prolong application of the brakes. The survey responses suggest that the braking system should be inspected and serviced periodically in order to minimize the rate of brake failure in mini-buses.

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